

Section E

Electrical

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Description	Current track	Description	Current track
A - Battery	23	M ¹⁷ - Backup light, right	50
B - Starter	24, 25	N - Ignition coil	53
C - Generator	20, 21, 22	N ¹ - Automatic choke	55
C ¹ - Regulator	20, 21, 22	N ² - Electromagnetic pilot jet	56
D - Ignition/starter switch	8, 24, 25, 26	O - Distributor	53, 54
E - Windshield wiper switch	44, 45	P - Spark plug connectors	54
E ¹ - Light switch	8, 12, 13, 16	Q - Spark plugs	54
E ² - Turn signal and headlight dimmer switch	3, 37, 38	S ¹	2, 6, 7, 8,
E ³ - Emergency flasher switch	32, 36, 37, 38, 39, 41	to - Fuse box	17, 19, 42,
F - Brake light switch	47, 48	S ¹⁰	46
F ¹ - Oil pressure switch	29	S ¹³ - Fuse for backup lights (8 amp.)	49
F ⁴ - Backup light switch	49	T - Wire adapter; behind dashboard	
G - Fuel gauge sending unit	27	T ¹ - Wire connector, single; behind the dashboard	
G ¹ - Fuel gauge	27	- in engine compartment, right side	
G ⁴ - Ignition timing sensor	54	T ^{1b} - in luggage compartment	
H - Horn button	46	T ^{1c} - in engine compartment	
H ¹ - Horn	46	T ² - Wire connector, double; in engine compartment lid	
J - Dimmer relay	3, 6, 8	T ³ - Wire connector, three connections in headlight housing, left and right	
J ² - Emergency flasher relay	31, 32, 33	T ⁴ - Wire connector, four connections in engine compartment	
J ⁶ - Fuel gauge vibrator	27	T ²⁰ - Test network, test socket	51
K ¹ - High beam warning light	4	U - Socket, accessory	2
K ² - Generator charging warning light	28	V - Windshield wiper motor	43, 45
K ³ - Oil pressure warning light	29	W - Interior light	1
K ⁵ - Turn signal warning light	30	X - License plate light	14, 15
K ⁶ - Emergency flasher warning light	35	Y ¹ - Terminal 58b of heater switch	11
K ⁷ - Dual circuit brake warning light	47, 48	Z - Connection of heater	1
L ¹ - Sealed beam unit, left headlight	6		
L ² - Sealed beam unit, right headlight	8		
L ⁶ - Speedometer illumination light	10, 11		
L ¹⁶ - Heater switch light	12	① - Ground strap battery-frame	23
L ²¹ - Light for heater lever illumination	41	② - Ground strap transmission-frame	20
M ² - Tail light, right	16	④ - Ground strap steering coupling	
M ⁴ - Tail light, left	19	⑩ - Ground connection, dashboard	
M ⁵ - Turn signal and parking light, front left	17, 37	⑪ - Ground connection, speedometer	
M ⁶ - Turn signal, rear left	36		
M ⁷ - Turn signal and turning light, front right	18, 38		
M ⁸ - Turn signal, rear right	39		
M ⁹ - Brake light, left	48		
M ¹⁰ - Brake light, right	47		
M ¹¹ - Side marker light, front left and right	17, 18		
M ¹⁶ - Backup light, left	49		

Test network

the orange colored spots are the connections in the test network which are wired to the test socket - T²⁰ - .
The numbers in the spots correspond to the terminals in the test socket.

Wire color (corresponds with color in vehicle)

Wire cross section in mm²

Part designation

Helps you to find, in the legend, the part which the symbol in the diagram belongs to, e.g.
E⁹ = Switch for fan motor.

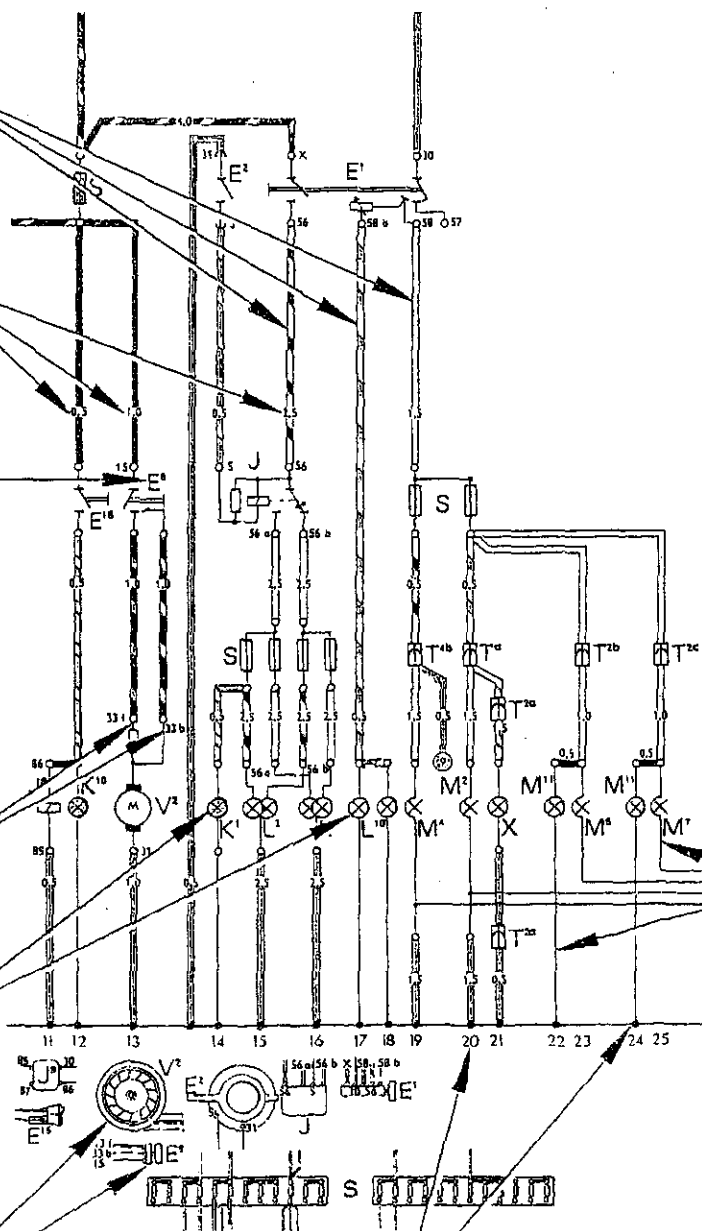
Terminal with the designation which is on the actual part.

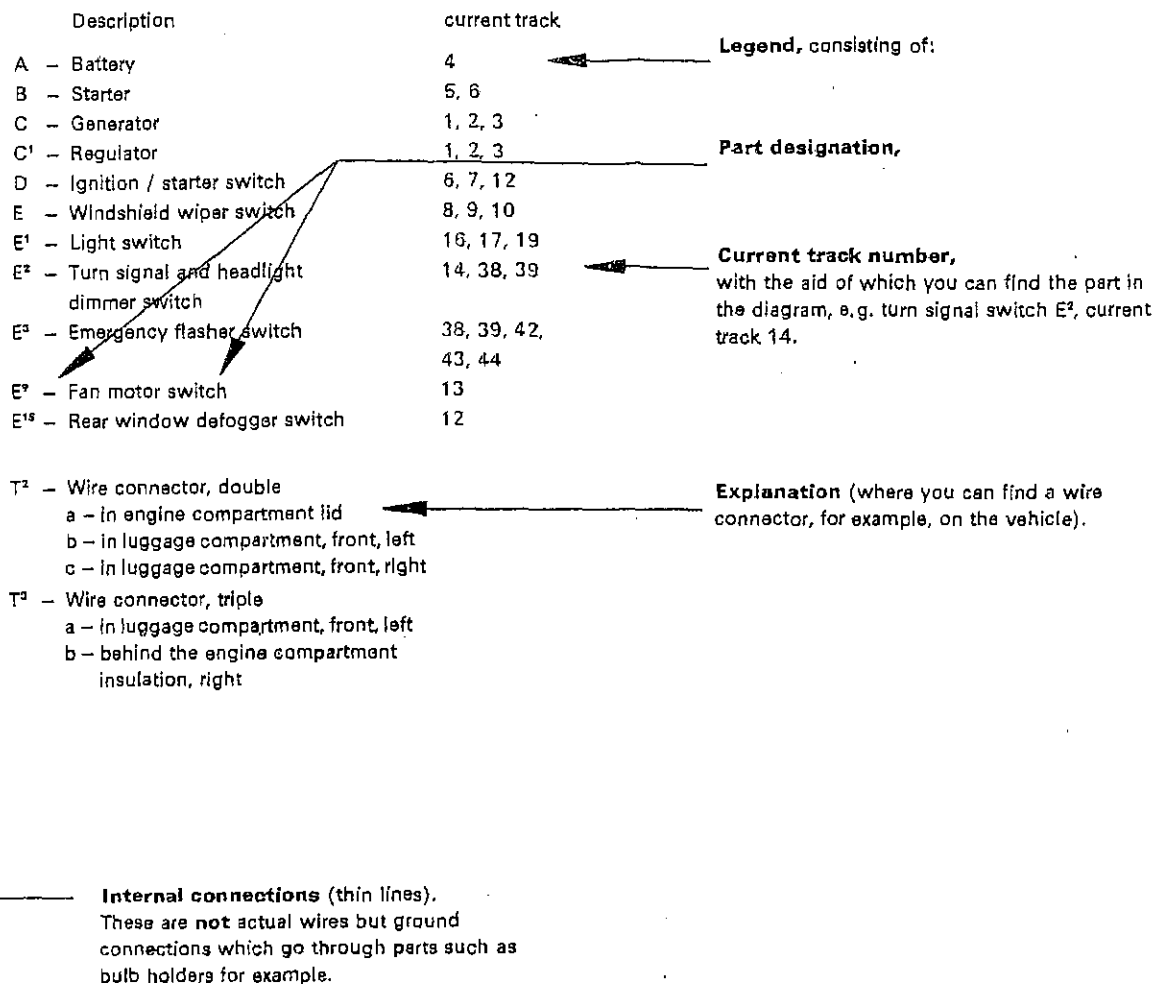
Symbol (here: Bulb)

Sketch of part, the symbol for which is in the current track above it. Also shows how wires are connected.

Current tracks with track numbers to facilitate finding of part in diagram (see legend).

- Des
- A - Batt
 - B - Star
 - C - Gen
 - C' - Reg
 - D - Igni
 - E - WIn
 - E' - Light
 - E² - Turn dim
 - E³ - Em
 - E⁹ - Fan
 - E¹⁸ - Rea
 - T² - Wir a b c
 - T³ - Wir a b

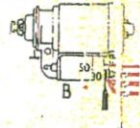
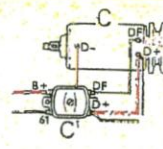
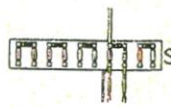
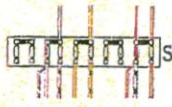
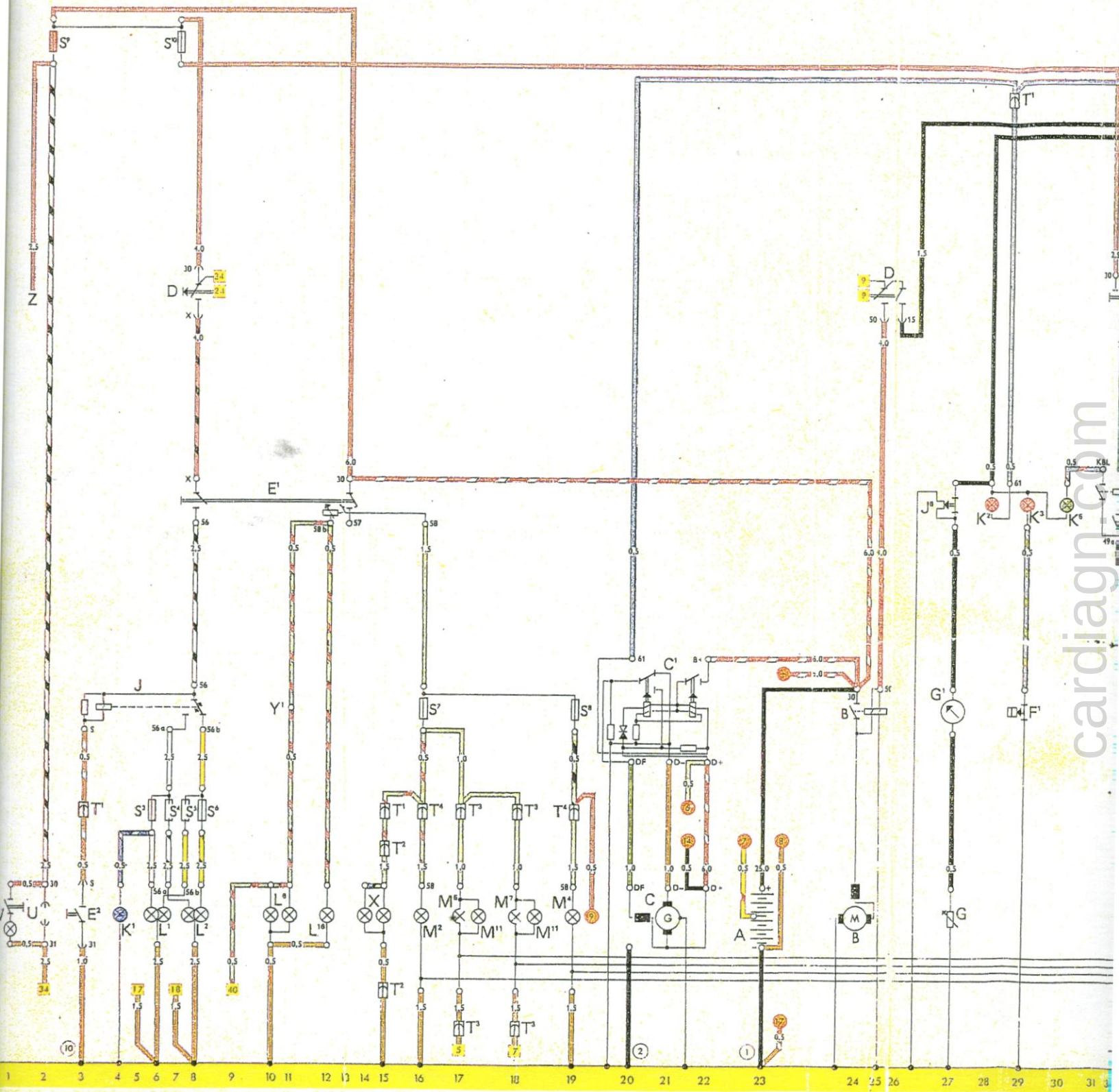




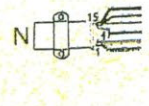
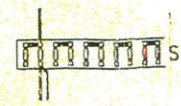
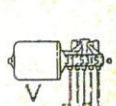
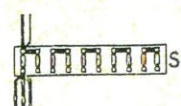
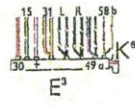
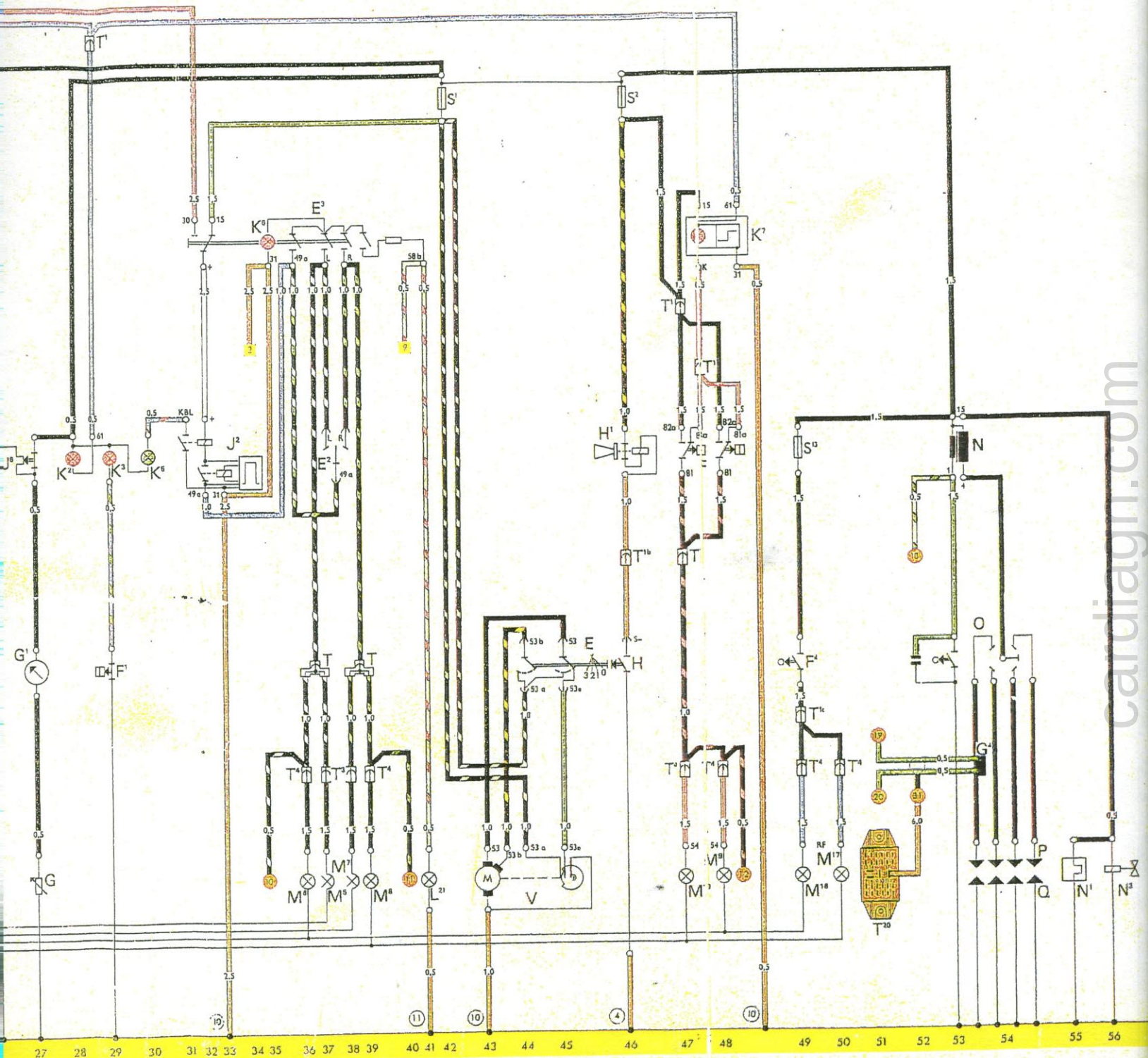
Please note:

All switches and contacts are in a mechanically
neutral position.

The various contacts in switches are shown in
the current track in which they operate.



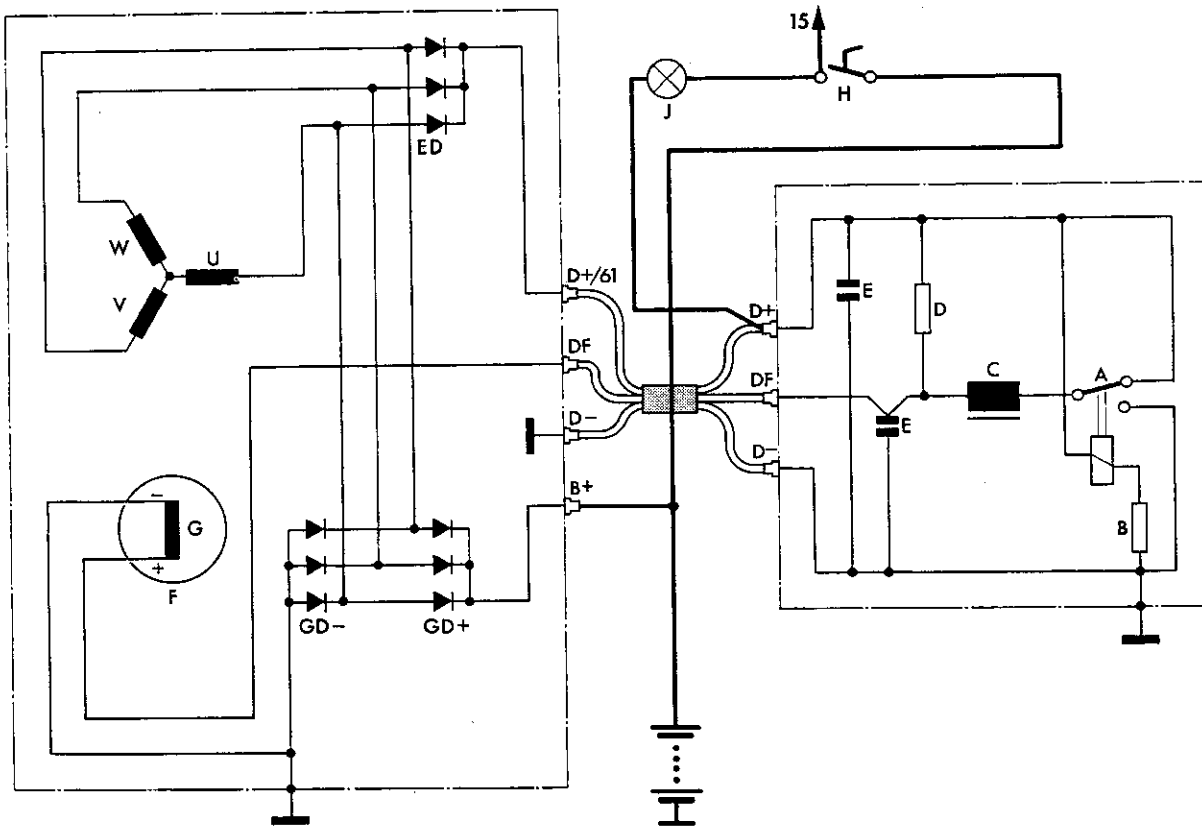
cardiagn.com



Wiring Diagrams **E1.2**

	Antenna		Heating resistor (element)
	Dipole antenna		Danger! High Voltage
	Direct current		Spark gap
	Alternating current		Condenser
	Three-phase current		Feedthrough (suppressor) condenser
	Generator		Coil, iron core
	Battery cell		Transformer, iron core
	Motor		Diode
	Measuring gauge		Zener diode
	Voltmeter		Transistor
	Ammeter		Thyristor
	Wiring		Mechanical connection of components
	Wire cross section in mm²		Mechanical connection, spring loaded contact
	Wire junction, fixed		Time switch
	Wire connector, separable		Manually operated switch
	Wire junction, separable		Mechanically operated switch
	Suppression wire		Motor operated switch
	Wire crossing		Relay coil
	Ground		Solenoid coil
	Switch position, open		Relay, electrothermal
	Switch position, closed		Relay, electromagnetic
	Multiple contact switch		Electromagnetic valve (jet)
	Fuse		Boundary line for an assembly
	Light bulb		Horn
	Glow lamp		Loudspeaker
	Resistor		
	Potentiometer		
	Tapped resistor		
	Thermal resistor, automatically regulating		

Description	Type 1	Type 2	Type 3	Type 4
Generator				Alternator
Maximum current	30 amp	30 amp 38 amp	30 amp	55 amp
Mean regulating voltage	14 V	14 V	14 V	14 V
Nominal output speed	2000 rpm	2000; 2400 rpm	2000 rpm	2000 rpm
Cut-in speed	1450 rpm	1450; 1300 rpm	1450 rpm	1000 rpm
Ratio	1.8:1; 1.9:1	1.9:1	2.3:1	2.26:1
Battery	12 V; 45 Ah	12 V; 45 Ah	12 V; 45 Ah	12 V; 45 Ah
Starter	12 V; 0.7 hp (Automatic Stick Shift 0.8 hp)	12 V; 0.7 hp	12 V; 0.7 hp (Automatic 0.8 hp)	12 V; 0.7 hp (Automatic 0.8 hp)
Windshield wiper motor				
Current draw	12 V low speed approx. 2 amp high speed approx. 3 amp	12 V low speed approx. 2.5 amp high speed approx. 3.5 amp	12 V low speed approx. 2.5 amp high speed approx. 3.5 amp	12 V low speed approx. 2.5 amp. high speed approx. 3.5 amp
Windshield washer				
Maximum pressure	pneumatic 3 kg/cm ² (43 psi)	pneumatic 3 kg/cm ² (43 psi)	pneumatic Sedan: 3 kg/cm ² (43 psi) Wagon: 4 kg/cm ² (56 psi)	pneumatic Sedan: 3 kg/cm ² (43 psi) Wagon: 4 kg/cm ² (56 psi)
Capacities	2.1 US pts	3.2 US pts	2.1 US pts	3.2 US pts
Sealed beam unit	12.8 V; 50/40 W	12.8 V; 50/40 W	12.8 V; 50/40 W	12.8 V; 50/37.5 W
Turn signal/parking light bulb	12 V; 21 W	12 V; 21 W	12 V; 21 W	12 V; 21 W
Stop/tail light bulb	12 V; 21/5 W	12 V; 21/5 W	12 V; 21/5 W	12 V; 21/5 W
License plate light bulb	12 V; 10 W	12 V; 10 W	12 V; 5 W Squareback Sedan 12 V; 10 W	12 V; 10 W Wagon: 12 V; 5 W (two)
Back-up light bulb	12 V; 25 W	12 V; 25 W	12 V; 25 W	12 V; 25 W
Interior light bulb	12 V; 10 W	12 V; 10 W	12 V; 10 W	12 V; 10 W
Side marker light bulb	12 V; 4 W	12 V; 4 W	12 V; 4 W	12 V; 4 W
Warning light bulb	12 V; 2 W 12 V; 1.2 W	12 V; 1.2 W	12 V; 2 W 12 V; 1.2 W	12 V; 1.2 W
Speedometer range	0-90 mph	10-90 mph	0-90 mph	0-110 mph
Clock	-	electric	electric	electric
Fuel gauge	thermo-electric	electric	electric	electric
Heated rear window	12 V; 60 W	12 V; 60 W	12 V; 60 W	12 V; 80 W
Fresh air fan low speed	2 amp	2 amp	2 amp	2 amp
Current draw high speed	2 amp	3 amp	3 amp	3 amp
Fuse box	10 fuses	10 fuses	12 fuses	12 fuses



- A - Regulator contact
- B - Compensating resistance
- C - Choke
- D - Resistance
- E - Condensers
- ED - Exciter diodes

- F - Rotor
- G - Exciter winding
- GD - Rectifier diodes
- H - Ignition switch
- I - Generator charging warning lamp
- K - Battery
- U, V, W - Stator windings

The terminals on the regulator and alternator are plug combinations that cannot be mistaken.

A mechanical, single-contact voltage regulator (Bosch type ADN) is installed. The reverse current relay necessary for regulators of direct current generators is not required for alternators because the rectifier diodes prevent the battery from being discharged through the alternator windings.

One peculiarity of the alternator must be mentioned at this point: For weight reasons, the rotor (field winding) contains less iron than the pole shoes of a comparable direct current generator. When the alternator starts, the residual magnetism is often not sufficient to induce exciter voltage in the stator windings. For this reason, the field winding is provided with voltage from the positive battery terminal through the ignition switch, charging warning light, terminal B + /61, regulator, and alternator terminal DF. This voltage is sufficient to excite the stator winding. As the alternator rpm increases, the voltage at terminal D + increases to the voltage of the battery. At this moment, the charging warning light goes out. It is important the charging warning light have an input of 1.2 Watt.

DC generators, regulators

Vehicle Type	Generator VW Part No.	Regulator VW Part No.	Installed Chassis No. from to	Maximum current A	Nominal Data Mean regulating voltage V	Nominal output speed rpm
1	211 903 031	211 903 803	117 000 001 – 117 844 902	30	14	2000
	211 903 031 A	211 903 803 B	118 000 001 – 118 857 871	30	14	2000
	113 903 031 G	113 903 803 E	118 857 872 –	30	14	2000
2	211 903 031	211 903 803	216 052 244 – 217 148 459	30	14	2000
	211 903 031 A	211 903 803 B	218 000 001 – 218 163 485	30	14	2000
	113 903 031 G	113 903 803 E	218 163 486 – 218 202 251	30	14	2000
	211 903 031 D	211 903 803 E	219 000 001 – 211 227 6560	38	14	2400
3	311 903 031 E	211 903 803 and B	317 000 001 – 318 191 403	30	14	2000
	311 903 031 F	113 903 803 E	318 191 404 –	30	14	2000

General testing instructions

To determine the condition of the generator, the following tests must be made:

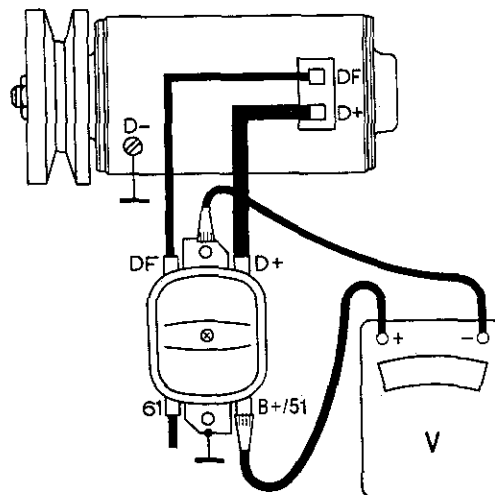
- 1 – No-load voltage
- 2 – Regulating current (load current given in chart "Test data" on page E 2.5/1–1)
- 3 – Cut-in voltage
- 4 – Return current

Testing no-load voltage

Note

The cut-in speed of the early cut-in generator is so low that in some cases it may be necessary to adjust the engine to the slowest possible idle speed.

- 1 – Disconnect wire from regulator terminal B+ making certain not to ground lead. Connect voltmeter positive terminal to regulator terminal B+ (51) and voltmeter negative terminal to ground.
- 2 – Start engine. Slowly increase engine speed to approximately 1700 to 2000 rpm. The voltmeter should show 12 to 14 volts (for specific readings see test data chart, page E 2.5/1).
- 3 – When the engine is turned off, the voltmeter reading should drop from 12 to 0 volts just before the engine stops completely. This is an indication that the regulator points are not sticking.

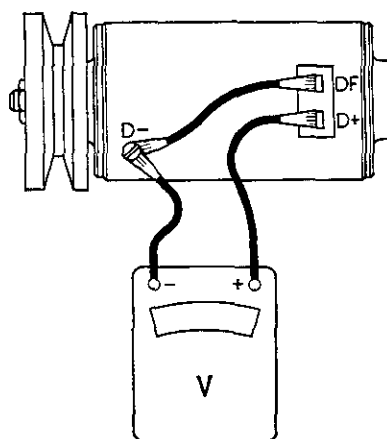


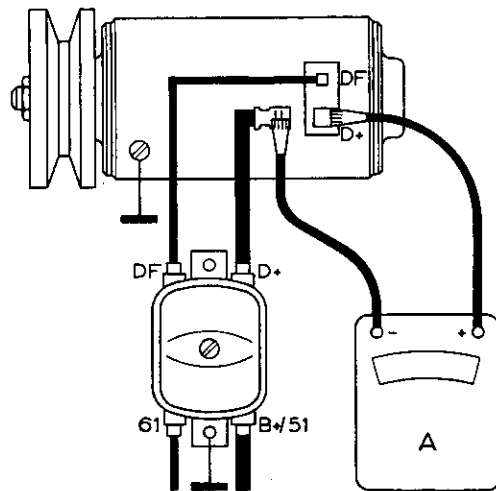
Testing generator without regulator (quick check)

- 1 – Disconnect both leads (D+ and DF) from generator.
- 2 – Connect terminal DF of generator (small push-on connection) to ground (D-).
- 3 – Connect positive lead of voltmeter to large push-on connector (D+) of generator and the negative lead to the (D-) terminal.
- 4 – Run the generator briefly at the following speeds. The voltage supplied by the generator must be as follows:

Rpm	Voltage
1500	12 volts
3000	36 volts

- 5 – If the generator supplies no voltage or too little voltage, it must be removed and checked. (See "Testing Instructions" generator removed, E 2.4/1).

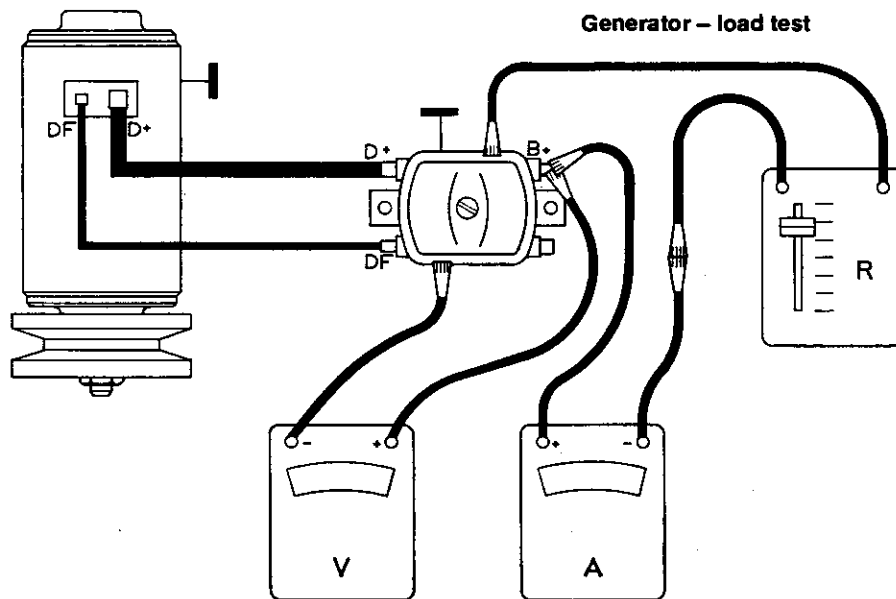




Testing for return current

The D + terminals on the regulator and on the generator must not be disconnected with the engine running otherwise the field windings of the generator will burn out.

- 1 – Disconnect D + lead from generator. Connect ammeter between lead and D + terminal, the positive ammeter lead to terminal D +, the negative ammeter lead to disconnected wire (range of ammeter should be 15–50 amps.).
- 2 – Start vehicle engine and allow to run at fast idle.
- 3 – Reduce idle until ammeter moves to negative range (see test data chart). Then turn the engine off. The ammeter must jump back to zero before the engine comes to a complete stop.
- 4 – If the ammeter does not return to zero when the engine is at a complete stop, the regulator is defective and must be replaced.



Generator – load test

A quick test can be made to determine generator output. For this test a voltmeter (range 0–30 volts), an ammeter (range 10–50 amps.) and a rheostat (that can be loaded to 50 amps.) are required. No 9 AWG (minimum) wire must be used for current measurements.

- 1 – Connect leads to regulator terminal B + /51.
- 2 – Connect voltmeter, ammeter and rheostat as shown in the illustration.
- 3 – Start engine, bring engine speed to approximately 3000 rpm. Adjust rheostat to proper load current setting (see test data chart). Now the regulating voltage (under load) can be measured.

Checking brushes and commutator

Examine brushes for wear. If they no longer protrude from the holders they must be replaced. (See parts list for proper generator brushes.)

To remove: lift the retaining spring with a wire hook and pull the brushes out of the holders. Remove the brush leads being sure not to drop screws or lock washers into generator housing.

Note

If the commutator is oily or dirty it can be cleaned with a suitable solvent.

If the commutator is scored or burnt disassemble the generator and recondition it.

If the brush springs have to be replaced or the commutator has to be repaired, the generator must be removed.

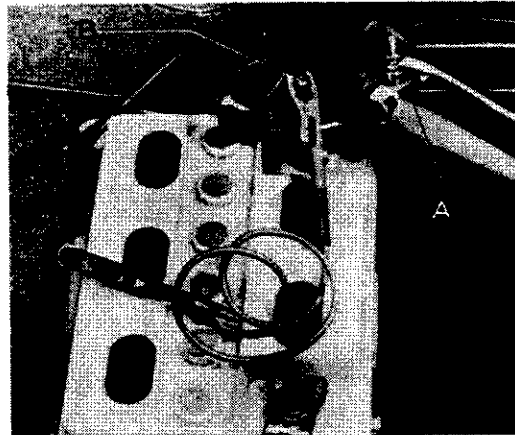
Alternator and regulator, testing instructions**Caution**

Never run alternator with battery disconnected

When testing the alternator, the instrument leads must be securely connected while the alternator is stationary.

Testing regulating voltage under load

- 1 – Disconnect positive battery cable.
- 2 – Connect battery cutout switch to positive battery terminal.
- 3 – Connect positive terminal to battery cutout switch (switch is on).
- 4 – Disconnect black/red wire (power supply to fuel injection control unit) from battery positive terminal. Connect positive terminal with wires for starter and fuse box to battery cutout switch (A). Connect the black/red wire to the center pole of the cutout switch (B) with an alligator clip.

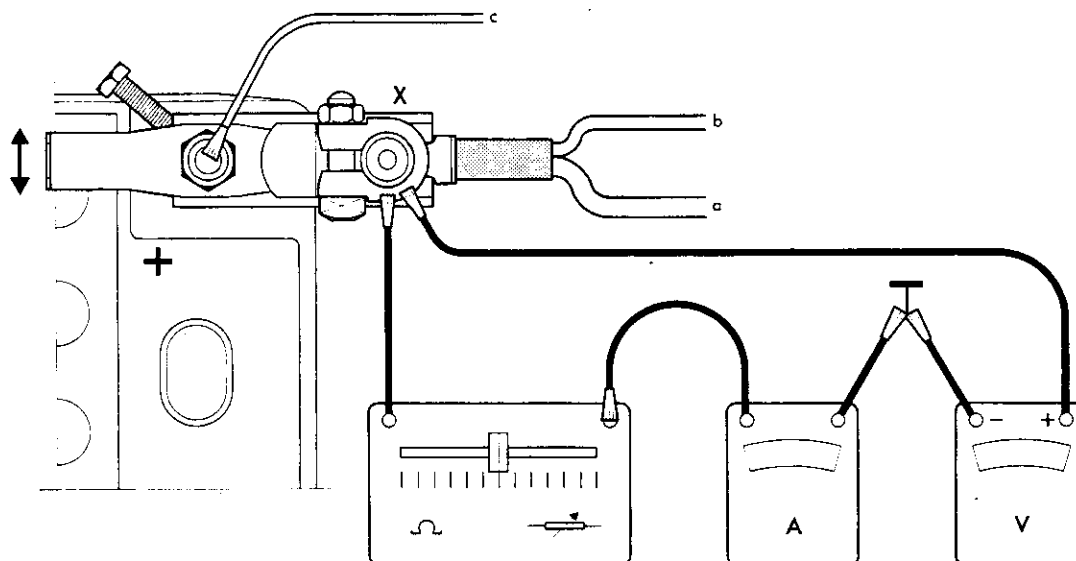
**Note**

The direct connection of the power supply for the fuel injection control unit to the battery positive pole is necessary in order to separate the control unit supply from the alternator during the check.

This prevents disturbances in the alternator voltage from causing the engine to misfire.

E2.3

Generator, Alternator, Regulator



- a – to starter
- b – to light switch terminal 30
- c – to fuel injection control unit
- x – battery cutout switch
(SUN electric No. 7052-003 or similar equipment)

- 5 – Connect ammeter, voltmeter and load resistance as shown (load resistance is connected to positive terminal).
- 6 – Start engine and run it at 2000 rpm.
- 7 – Adjust load resistance to give a reading of 20 amps. on the ammeter.
- 8 – Operate switch to cut battery out of test circuit. The load current is now determined by the load resistance.
- 9 – Regulate load resistance and set to 25–30 A.
- 10 – Regulating voltage should be 13.9–14.8 Volts. It should be read within 30 seconds so that the regulator does not have time to warm up.

If there are deviations from the prescribed values, install a new regulator and repeat the test. If there are still deviations, test the alternator. This is best done with an oscilloscope. If this is not available, the alternator must be removed and tested as described on page E 2.4/2.

REMOVING

Caution

The negative battery strap must be removed before disconnecting the wires on the regulator. If this is not done the generator and/or regulator can be damaged.

Installing

When installing the regulator make sure it has a good ground connection and that all the wires are hooked up correctly according to the wiring diagram. If leads DF and D + or B + (51) and 61 are interchanged, the generator and/or regulator will be damaged.

Regulator connections:

D+ to generator D+ and connection No. 6 of test network

DF to generator DF

B+/51 to negative battery terminal and to terminal 30 of the electrical system

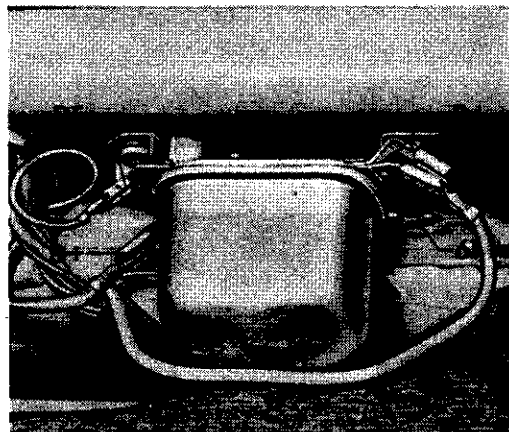
61 to generator charging warning light

Type 1

The regulator is installed on the left under the rear seat.

From November 1971 the connector of terminal DF is protected by a cap.

It can also be service installed on earlier models.

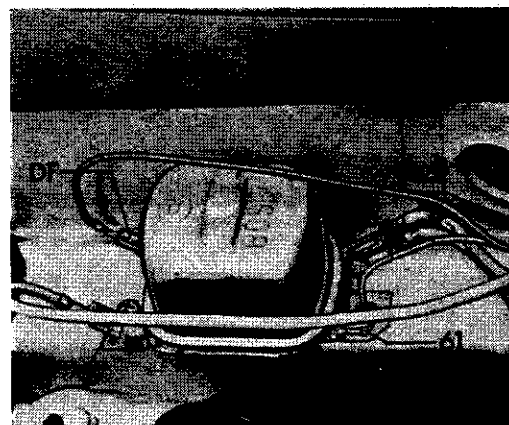


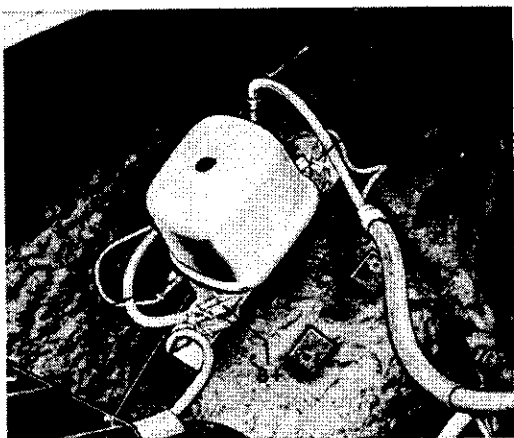
Type 3

The regulator is installed on the left under the rear seat.

From November 1971 the connector of terminal DF is protected by a cap.

It can also be service installed on earlier models.



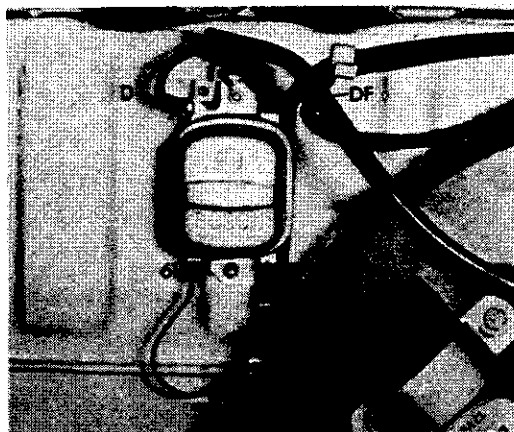


Type 1 /Karmann Ghia

The regulator is installed in the engine compartment.

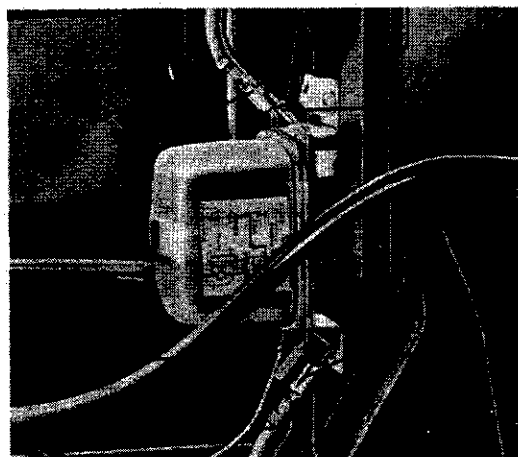
From November 1971 the connector of terminal DF is protected by a cap.

It can also be service installed on earlier models.



Type 1 /Model 181

The regulator is installed in the engine compartment.



Type 2

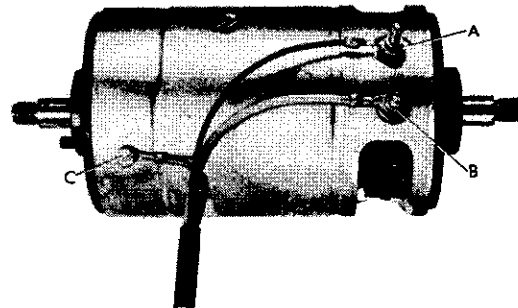
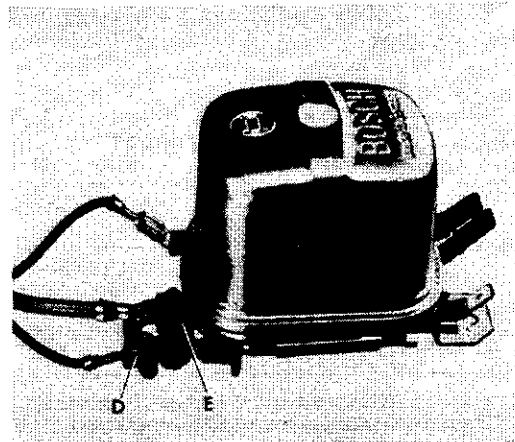
The regulator is installed in the engine compartment.

From November 1971 the connector of terminal DF is protected by a cap.

It can also be service installed on earlier models.

Note

Since March 1968, the D + and DF terminals of the generator and the D + terminal on the regulator have been changed from the push-on type to the screw type. An additional ground wire has been fitted between generator and regulator.



If generators or regulators with push on connectors are replaced by screw type connectors, use the following parts:

Illustration letter	Terminal	Wire terminal	Dished washer	Lock washer	Nut	Fillister head screw
A	generator DF	111971949*	Cannot be lost		Cannot be lost	
B	generator D +	111971945 B	N 122251		N 110052	
C	generator D -	111971949		N 120051		N 107042
D	regulator D -	111971949	N 122251			N 108861
E	regulator D +	111971945 B	N 122251			N 108861

* Cut open

If a regulator is replaced on a vehicle without a ground wire between regulator and generator, install a wire between regulator and body in addition to the existing ground connection (attaching bolts).

E2.9

Generator, Alternator, Regulator

The chart shows which units interchange with the new units.

	Previous (push-on)	New (screw type)	Installed in:
Generator	211903031	113903031 G	Type 1 from Aug. 1967 and Type 2 from Aug. 1966,
	211903031 A		Type 2 up to July 1968
	311903031 E*	311903031 F*	Type 3 from Aug. 1966
	311903017 D**	311903017 F**	
Regulator	211903803	113903803 E	Types 1, 2 and 3
	211903803 B		

* These generators are installed in production and marked with this number.

** These generators are supplied as spare parts (with installed and balanced pulley).

Type/Model	from Chassis No.	Starter	Voltage/ Nominal output	Remarks
1	118000001	311911023 B (Bosch) 111911023 A (VW)	12 v / 0.7 hp	
2	218000001			
3	318000001			
4	419000001			
1	110200001	311911023 C (Bosch)	12 v / 0.7 hp	aluminium field coils
2	210200001			
3	310200001			
4	410200001			
1	From March 1970	311911023 D (Bosch)	12 v / 0.7 hp	aluminium field coils, short housing
2				
3				
4				
1/Automatic Stick Shift	118000002	003911023 A (Bosch)	12 v / 0.8 hp	
1/Model 181	180300001			
2/Automatic	213200001			
3/Automatic	318000002			
4/Automatic	419000002			

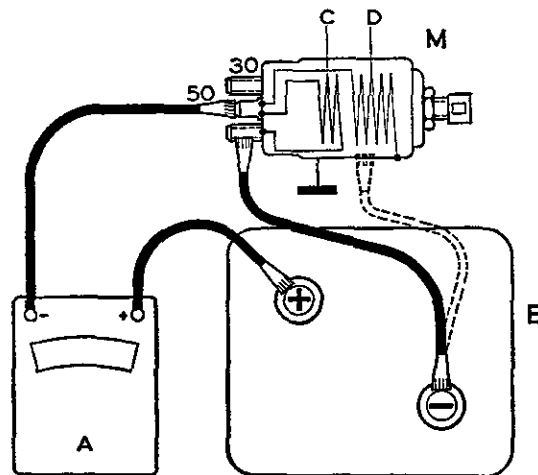
Testing solenoid switch

To test the two windings of the solenoid switch, measure the current consumption by connecting an ammeter and battery as illustrated.

Solenoid switches with faulty pull-in or holding windings cannot be repaired.

Testing Bosch solenoid switch:

- 1 - Test pull-in winding (maximum 35 amp.).
- 2 - Test holding winding (maximum 11 amp.). Battery negative terminal connected to switch housing (see dotted lines on drawing).



A = Ammeter
B = Battery
C = Pull-in winding

D = Holding winding
M = Solenoid switch

Starter

Starter type	No load test			Load test			Stall torque test		Pull-in voltage solenoid switch
	Current amps.	Volt-age	Speed rpm	Current amps.	Volt-age	Speed rpm	Current amps.	Volt-age	
311911023 B 311911023 C 311911023 D	35-45	12	7400-9100	170-205	9	900-1300	220-260	6	7
111911023 A	25-40	12	6200-7800	170-195	9	1050-1350	270-290	6	8
003911023 A	35-50	12	6400-7900	160-200	9	1100-1400	250-300	6	8

These values are for a 12 Volt, 135 Ah battery (If necessary, connect batteries in parallel).

All speeds are starter shaft speeds.

Test temperature 68° F (20° C.)

Solenoid switch

Current draw (amps.) 12-volt solenoid switch		
	Bosch	VW
Pull-in winding, max.	max. 35	max. 30
Holding winding, max.	max. 11	max. 12

Note

When connecting test equipment be sure to follow instructions supplied by the manufacturer of same.

Symptoms	Cause	Remedy
Starter does not turn when ignition switch is operated	Turn on the lights when testing:	
	a – Lights do not burn. Loose cables or poor ground connection. Battery discharged	a – Check battery cables and connections. Test voltage of battery, charge if necessary
	b – Lights are on but go out when starter switch is operated. Insufficient current due to loose connections or corroded terminals	b – Clean battery terminals and cable clamps. Tighten connections between battery, starter and ground
	c – Lights go dim when starter switch is operated. Battery run down	c – Charge battery
	d – Lights burn brightly. Starter turns when terminals 30 and 50 are bridged. Wire from terminal 50 to starter switch faulty	d – Eliminate open circuits, replace faulty parts
	e – Lights stay bright and solenoid switch operates. Disconnect battery cable from terminal 30 at starter and connect it directly to the connector strip terminal. If the starter operates the contacts of the solenoid switch are worn or dirty	e – Replace solenoid switch
	f – Automatic Stick Shift: corroded connections in starter cut-out switch	f – Replace corroded parts, wrap insulating tape around connection between insulating sleeving and rubber cap
Starter does not operate when battery cable is connected directly to the connector strip terminal	a – Brushes sticking	a – Clean brushes and brush guides
	b – Brushes worn	b – Replace brushes
	c – Weak spring tension. Brushes do not make contact	c – Replace springs
	d – Commutator dirty	d – Clean commutator
	e – Commutator grooved or burned	e – Overhaul starter armature
	f – Armature or field windings faulty	f – Overhaul starter
Starter turns slowly or does not turn engine	a – Battery run down	a – Charge battery
	b – Insufficient current flow due to loose or corroded connections	b – Clean battery terminals and cable clamps, tighten connections
	c – Brushes sticking	c – Clean brushes and brush guides
	d – Brushes worn	d – Replace brushes
	e – Commutator dirty	e – Clean commutator
	f – Commutator grooved or burned	f – Overhaul starter armature
	g – Armature or field windings faulty	g – Overhaul starter
Starter engages but cranks engine erratically or not at all	a – Drive pinion worn or damaged	a – Replace drive pinion
	b – Flywheel ring gear worn or damaged	b – Rework ring gear or replace flywheel if necessary
Starter drive pinion does not disengage	a – Drive pinion or armature shaft dirty or damaged	a – Overhaul starter
	b – Solenoid switch faulty	b – Replace solenoid switch

Symptom	Cause	Remedy
Starter does not turn when ignition switch is operated	Turn on the lights when testing: a - Lights do not burn. Loose wires or poor ground connection. Battery discharged b - Lights are on but go out when starter switch is operated. Insufficient current due to loose connections or corroded terminals c - Lights go dim when starter switch is operated. Battery run down d - Lights burn brightly. Starter turns when terminals 30 and 50 are bridged. Cable 50 to starter switch faulty, starter switch faulty e - Lights stay bright and solenoid switch operates. Disconnect battery cable from terminal 30 at starter and connect it directly to the connector strip terminal. If the starter operates, the contacts of the solenoid switch are worn or dirty	a - Check battery cables and connections. Test voltage of battery, charge if necessary b - Clean battery terminals and cable clamps. Tighten connections between battery, starter and ground c - Charge battery d - Eliminate open circuits, replace faulty parts e - Replace solenoid switch
Starter does not operate when battery cable is connected directly to the connector strip terminal	a - Brushes sticking b - Brushes worn c - Weak spring tension. Brushes do not make contact d - Commutator dirty e - Commutator grooved or burned f - Armature or field windings faulty	a - Clean brushes and brush guides b - Replace brushes c - Replace springs d - Clean commutator e - Overhaul starter armature f - Overhaul starter
Starter turns slowly or does not turn engine	a - Battery run down b - Insufficient current flow due to loose or corroded connections c - Brushes sticking d - Brushes worn e - Commutator dirty f - Commutator grooved or burned g - Armature or field windings faulty	a - Charge battery b - Clean battery terminals and cable clamps, tighten connections c - Clean brushes and brush guides d - Replace brushes e - Clean commutator f - Overhaul starter armature g - Overhaul starter
Starter engages but cranks engine erratically or not at all	a - Drive pinion worn or damaged b - Flywheel ring gear worn or damaged	a - Replace drive pinion b - Rework ring gear or replace flywheel if necessary
Starter drive pinion does not disengage	a - Drive pinion or armature shaft dirty or damaged b - Solenoid switch faulty	a - Overhaul starter b - Replace solenoid switch

Removing and installing starter

Note:

The starter is secured by two bolts. The upper bolt should be removed from the engine compartment (engine/transmission securing bolt).

When installing:

- 1 - Insert long bolt into mounting bracket hole and together with starter into transmission housing.
- 2 - After installation, seal mating surface of mounting bracket and transmission housing with housing sealing compound D 3.
- 3 - Make sure connections are clean and tight.

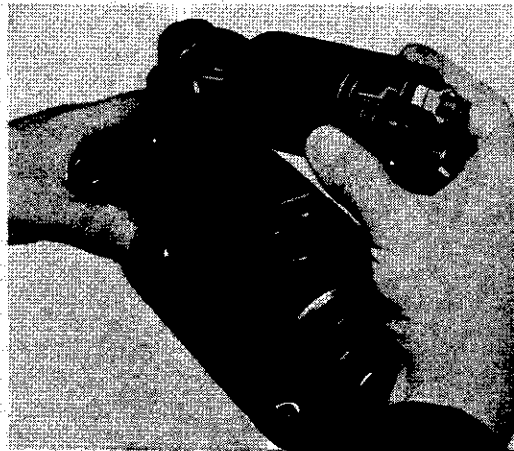
Removing and installing solenoid switch

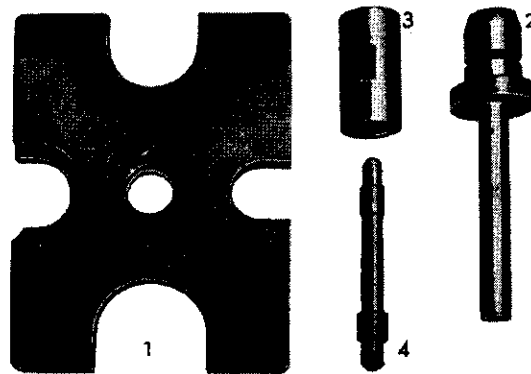
Removing

- 1 - The solenoid switch pull rod can be pulled out of the operating lever easier if the pinion is pulled forward and to the right at the same time.
- 2 - A faulty solenoid switch should be replaced.

Installing

- 1 - Make sure rubber gasket on starter mounting bracket is properly seated.
- 2 - Pull operating lever as far back as possible to allow installation of solenoid switch.
- 3 - Seal joint between solenoid switch and mounting bracket with D 3 sealing compound.

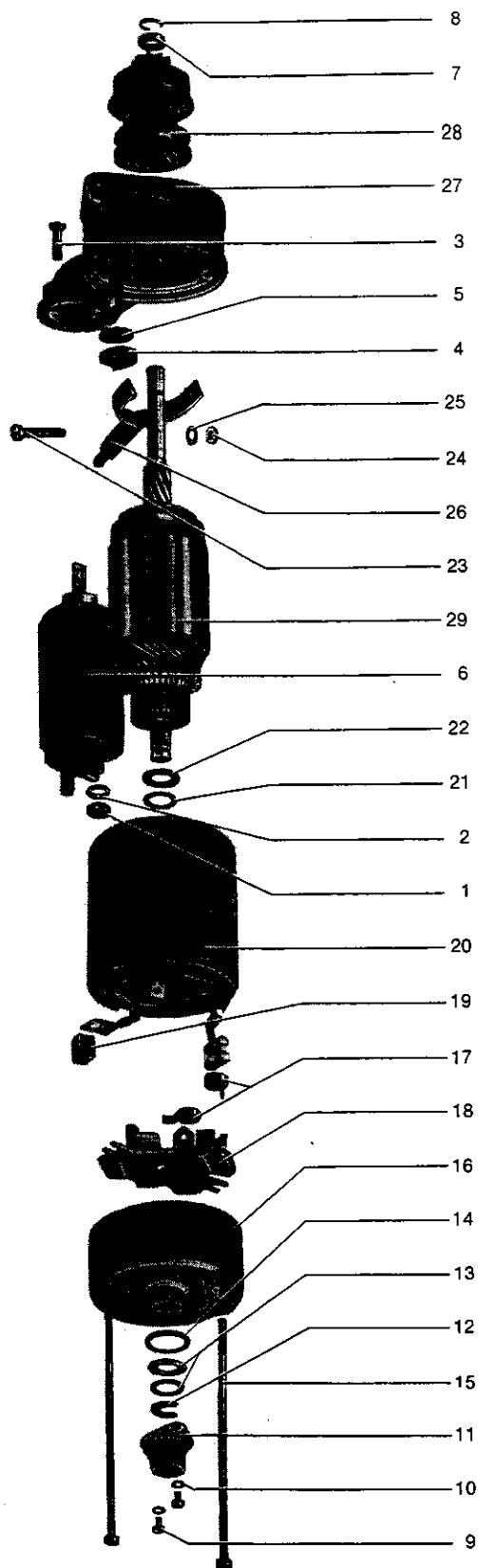




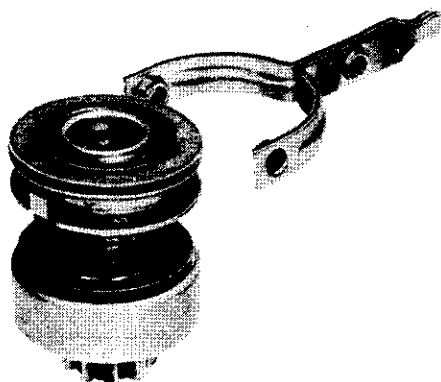
No.	Description	Special Tool No.	Remarks
1	Thrust plate	VW 401	
2	Punch	VW 411	
3	Tube	VW 418 a	32.5 mm (1.28 in.) diameter
4	Starter shaft bushing drift	VW 222 a	
5	Tube	VW 421	28 mm (1.1 in.) diameter

E3.7

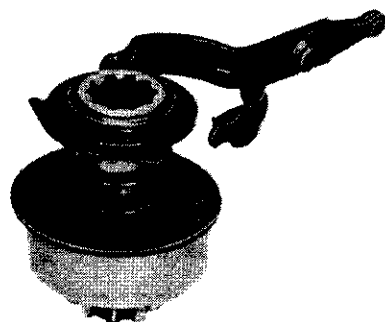
Starter



No.	Description	Qty.	Note when		Special instructions see
			disassembling	assembling	
1	Nut	1			
2	Lock washer	1			
3	Screw	2			
4	Rubber seal	1			
5	Disc	1		projection faces upward	
6	Solenoid switch	1	pull out pinion	pull out operating lever	
7	Stop ring	1	drive back with VW 421	annular groove faces outward	
8	Circlip	1	use circlip pliers		
9	Screw	2			
10	Washer	2			
11	End cap	1			
12	C-washer	1			
13	Shim		note quantity of shims	adjust axial play to 0.1–0.3 mm (0.004–0.012 in.) with shims	
14	Sealing ring	1			
15	Housing screw	2		seal screw 32 mm (1.259 in.) shorter for 311 911 023 D	
16	End plate	1	remove with VW 400, VW 401, VW 411, VW 418 and VW 222 a	check bushing for wear, lubricate bushing with multi-purpose grease	
17	Spring	2	lift brushes with wire hook		
18	Brush holder	1		check brushes for wear, brush pressure 1200 grams 311 911 023 C and D have four brushes	
19	Rubber grommet	1		check for tightness	
20	Housing	1		test field windings as on generator	
21	Insulating washer	1	note installation position	faces brush holder	
22	Thrust washer	1		faces commutator	
23	Pin	1			
24	Nut	1			
25	Lock washer	1			
26	Operating lever	1			
27	Mounting bracket	1		seal	
28	Drive pinion	1	replace if damaged	insert into mounting bracket from outside so that plastic washer contacts shoulder	
29	Armature	1	Note radial run-out and minimum diameter	electrical test, axial play 0.1–0.3 mm (0.004–0.012 in.)	



311911023 B



311911023 C
311911023 D



311911023 B



311911023 C
311911023 D

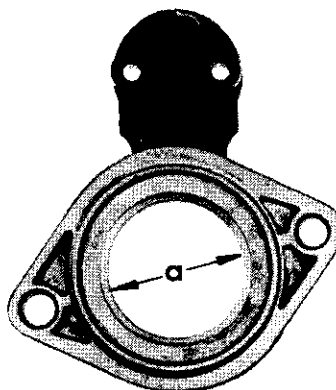
Starters 311911023 C and D have aluminium field coils instead of copper as in starters 311911023 B. Starters 311911023 D differ from the other Bosch starters by the 32 mm (1.259 in.) shorter housing.

The starters with aluminium field coils also differ from starters 311911023 B and from one another in the following parts:

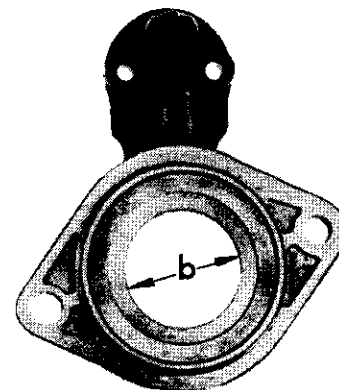
- 1 – The simplified drive has a drive plate and a thrust disc instead of a guide sleeve for the engaging fork. The fork has also been changed. When assembling, make sure that the plate and disc are passed through the fork. The ends of the fork must contact the two projections on the drive plate.

- 2 – By lengthening the slot in the solenoid pull rod it was possible to eliminate the switch-off spring in the pinion.

- 3 – The hole in the mounting bracket for the pinion has been reduced from 50 mm (1.968 in.) (a) to 43 mm (1.692 in.) (b).

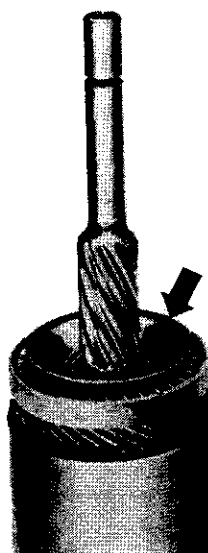


311911023 B

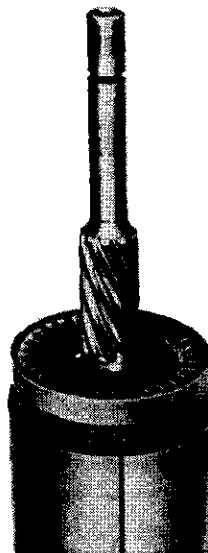


311911023 C
311911023 D

- 4 – On the modified starters the friction disc on the armature (arrow) was discontinued.



311911023 B

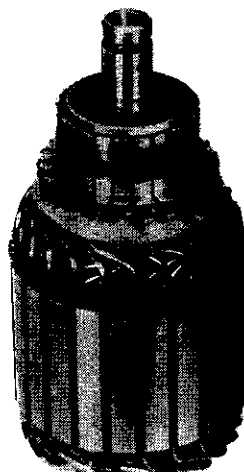


311911023 C



311911023 D

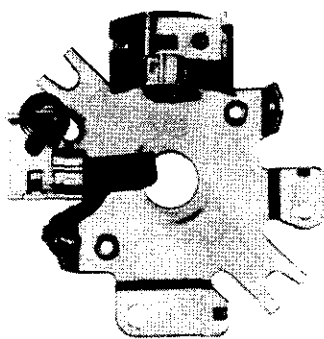
- 5 – The insulating and thrust washers between brush holder and commutator have been discontinued on starter 311911023 D. The function of these parts has been taken over by an insulating layer applied to the end face of the commutator.



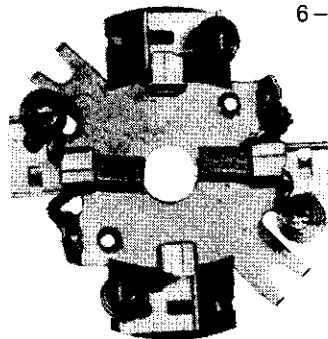
311911023 D



311911023 B
311911023 C

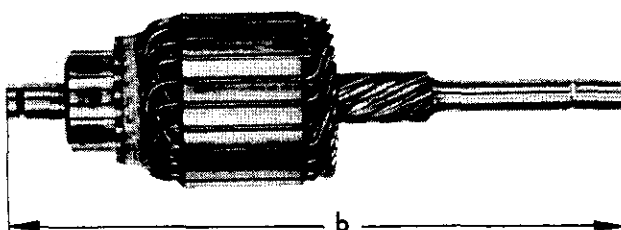


311911023 B



311911023 C
311911023 D

6 – The starter with aluminium field coils has four carbon brushes instead of two.

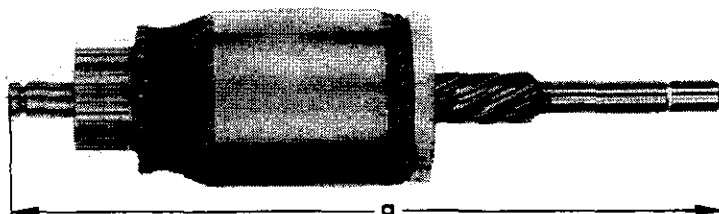


311911023 D

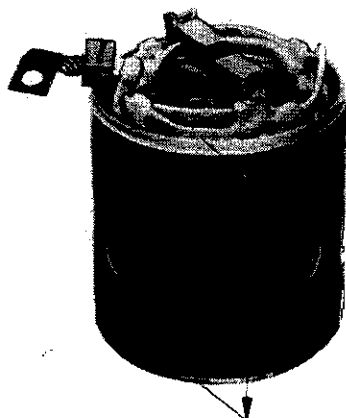
7 – Due to the shorter starter 311911023 D the armature, housing, field coils and mounting bracket were modified.

The new parts cannot be installed in starters 311911023 B and 311911023 C.

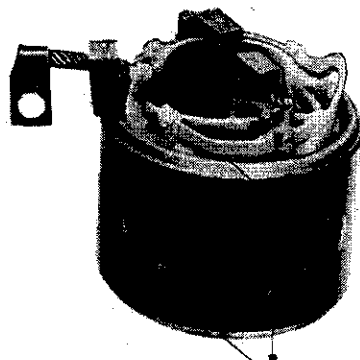
a – 245 mm (9.646 in.)
b – 213 mm (8.386 in.)



311911023 C
311911023 B



311911023 B
311911023 C



311911023 D

8 – Housing

a – 94 mm (3.700 in.)
b – 66 mm (2.598 in.)

9 – Mounting bracket

- a – 47 mm (1.850 in.)
b – 42 mm (1.653 in.)



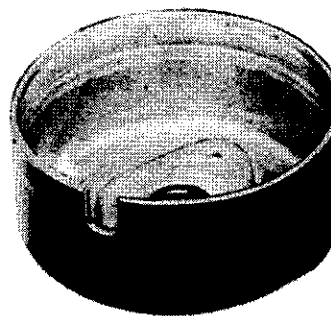
311911023 C



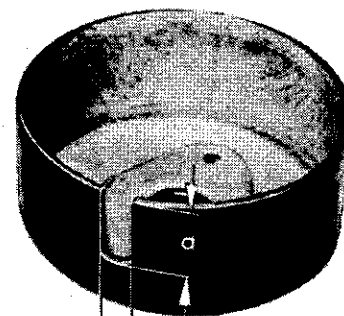
311911023 D

- 10 – The slot for the rubber seal in the commutator bearing has been lengthened 10 mm. When replacing this part, the slot in the bearing (113911235) must be lengthened as shown.

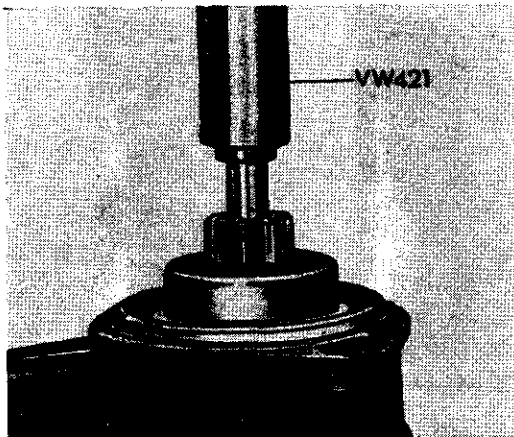
- a – 22 mm (0.866 in.)
b – 9 mm (0.354 in.)



311911023 C
311911023 B



311911023 D



Removing the pinion

- 1 – Hold armature downward and drive the pinion stop ring back by using VW 421.
- 2 – Remove the circlip with circlip pliers and pull stop ring off. Remove any burrs from circlip groove.
- 3 – If the pinion is faulty replace complete, because individual parts are not available.

Replacing carbon brushes

The carbon brushes can best be lifted with a wire hook.

Always use the correct carbon brushes for a particular starter, and then only exchange a complete set (see Parts Lists).

Checking commutator

If the commutator is oily or greasy, it can be cleaned with a cloth moistened with cleaning solvent.

If the surface of the commutator is uneven or shows signs of burning, turn the armature.

Testing armature and field winding

Damage to the armature and to the field windings is often not externally visible. The armature, commutator and field windings are tested as on the DC generator. The permissible commutator runout is 0.03 mm (0.001 in.) and the minimum diameter is 34.5 mm (1.358 in.).

Assembling

The individual parts should be washed in cleaning solvent and dried with compressed air. The commutator bushings should only be cleaned externally. The drive pinion should be washed in solvent if it is very oily and does not engage properly in cold weather.

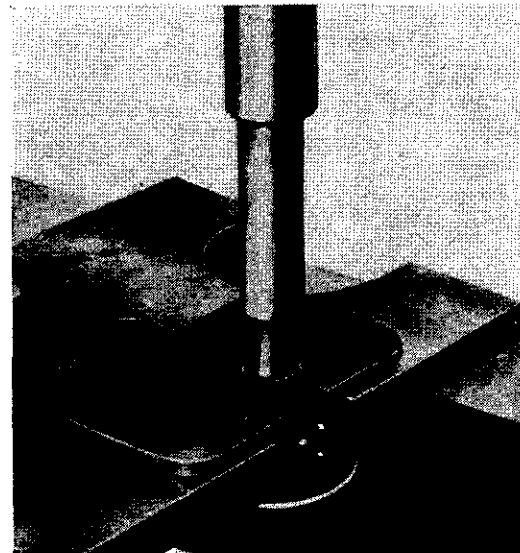
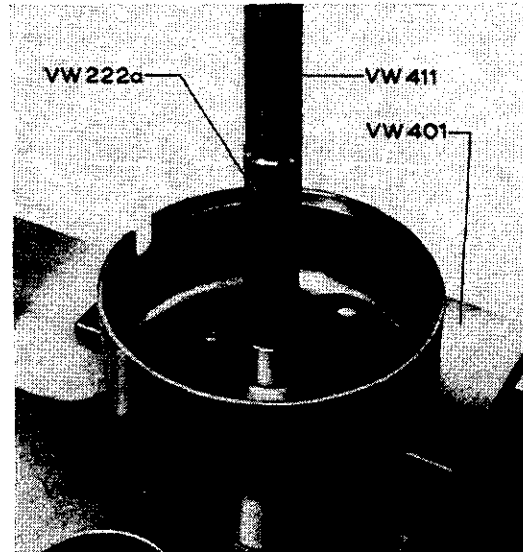
- 1- If the commutator bushing is worn, it should be removed and installed on repair press VW 400, using VW 401, 411, 418a and 222a.
- 2- Before installing a bushing, place end plate in hot oil.
- 3- Lubricate bushing in commutator end plate with multi-purpose grease.
- 4- Lubricate bearing surfaces, operating lever and drive pinion thread with universal grease.

When assembling, make sure that the rubber seal for the cable to the solenoid switch and the sealing ring for the end cap are properly seated.

Place stop ring onto armature shaft, install circlip and press stop ring over circlip.

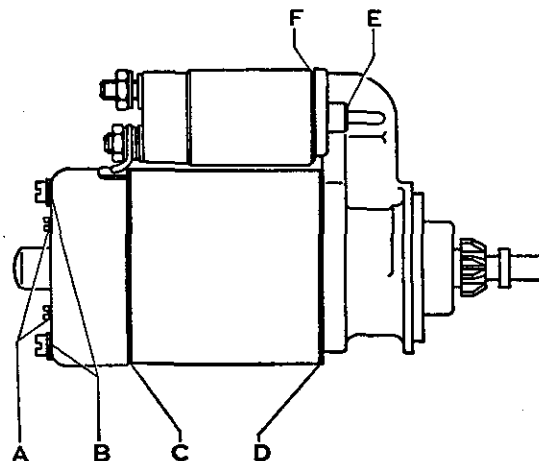
The stop ring must not jam and should be able to turn on the armature shaft.

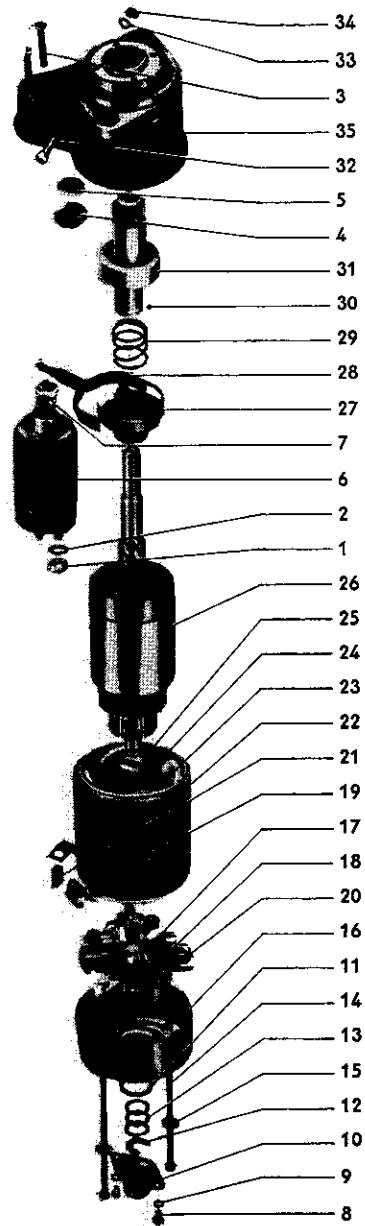
The axial play of the armature should be 0.1–0.3 mm (0.004–0.012 in.). If necessary adjust with shims.



To prevent starter damage due to water, the following locations should be sealed with VW housing sealing compound D 3.

- A – Holes for end cap screws.
- B – Holes for housing screws.
- C – Joint between housing and end plate.
- D – Joint between housing and mounting bracket.
- E – Holes for solenoid switch screws.
- F – The sealing surface between solenoid switch and mounting bracket should be sealed with VW plastic sealing compound D 14.





E3.7 Disassembling and Assembling

No.	Description	Qty.	Note when		Special instructions see
			disassembling	assembling	
1	Nut	1			
2	Lock washer	1			
3	Screw	2			
4	Molded rubber	1		insert tongue of rubber into cutout in pole housing	
5	Disc	1			
6	Solenoid return spring	1	pull pinion toward front	test current consumption of switch and check that core moves freely. Seal.	E 3.6/1-2 E 3.3/2-1
7	Solenoid return spring	1			
8	Fillister head screw	2			
9	Washer	2			
10	End cap	1		seal	E 3.7/1-4
11	Sealing ring	1	if damaged, replace		
12	C-washer	1			
13	Shim		note quantity of shims	adjust armature axial play to .004—.006 in. (0.1—.15 mm)	
14	Housing screws	2		seal with housing sealing compound D 3	E 3.7/1-4
15	Washer	2			
16	End plate	1	check bushing, replace if necessary, use VW 401, 411 and 418a	ground connection to pole housing must be clean. Seal after installing	E 3.7/1-4
17	Brush holder	1		ensure correct position of retainer and good ground connection to end plate	
18	Negative carbon brush	2	check for broken, dirty or unsoldered brushes	brushes must be able to move slightly in holder. Replace only in sets	
19	Positive carbon brush	2			
20	Retaining spring	4	lift with wire hook	brush pressure approx. 2.6 lb. (1200 grams)	
21	Rubber grommet	1		ensure good sealing	

No.	Description	Qty.	Note when		Special instructions see
			disassembling	assembling	
22	Pole housing	1		ensure good ground connection between end plate and drive end plate	
23	Field winding			test for open circuit, replace burnt winding	
24	Insulating washer	1		bears against brush holder	
25	Thrust washer	1		bears against commutator	
26	Armature	1	radial runout .002 in. (0.05 mm), minimum diameter 1.318 in. (33.5 mm), if necessary undercut segment insulation .031 in. (0.8 mm)	test for short circuit to ground, check soldered locations between segments and tabs. Install armature and engaging lever	
27	Operating sleeve	1			
28	Engaging lever	1		if engaging lever bent, fit new one	
29	Engaging spring	1			
30	Detent balls	10		insert with lithium grease	
31	Drive pinion	1			
32	Pin	1			
33	Lock washer	1			
34	Nut	1			
35	Drive end plate	1		seal joint between solenoid switch and pole housing	E 3.7/1-4

1 - Removing drive pinion:

Press operating sleeve against drive pinion and pull both off armature shaft by turning them slightly.

2 - Installing drive pinion:

Hold armature in vise, then push drive pinion and operating sleeve on armature shaft until the balls locate in the detent in the armature shaft. After releasing the drive pinion it must move freely on the armature shaft.

3 - Testing armature and field winding:

Damage to the armature and to the field windings is not often visible. The armature, commutator and field windings are tested as on the DC generator. The windings must not be burned or unsoldered and they must not project above the pole shoes. Check windings for breaks, particularly at the connections.

4 - Check brush holder for short circuit.

E3.7

Disassembling and Assembling

5 - Check armature for winding short circuit and/or short circuit to ground.

6 - Starter bushing:

Worn bushings must be replaced. The bushing must be flush on the inside. Use a suitable drift to press the bushing in and out.

When replacing the sintered metal bushing and the seal, the rivets in the mounting should be replaced by screws. Peen the screws.

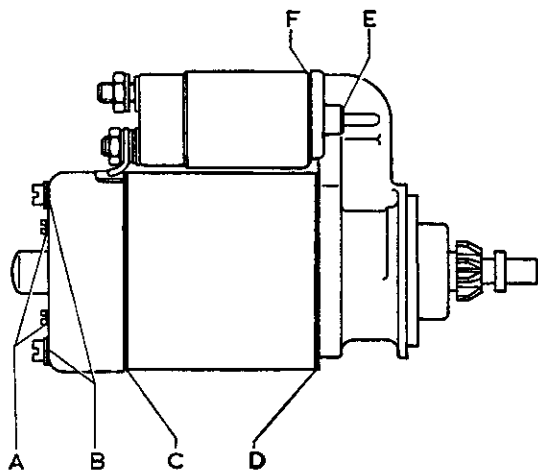
4 Fillister head screws M 4×10

4 Lock washers

4 Nuts

7 - Center the seal with a centering pilot.

8 - To prevent damage due to water, the following locations should be sealed with VW housing sealing compound D 3.



A = Holes for end cap screws

B = Holes for housing screws

C = Joint between pole housing and end plate

D = Joint between pole housing and mounting bracket

E = Holes for solenoid switch screws

F = The sealing surface between solenoid switch and mounting bracket should be sealed with VW plastic sealing compound D 14

Testing installed windshield wipers

Check windshield wiper operating condition by checking the current draw (at terminal 30) at low and high speed.

At low speed the current draw is about 2.5 amp. and at high speed 3.5 amp. These readings are attained with the wipers turned on and the blades pulled away from the windshield. Readings are inaccurate when the wipers press against the windshield due to the created friction.

If the wipers run slower and squeaking noises occur, along with a high current draw, the probable cause is a lack of bearing lubrication. If there is no squeaking noise but still a high current draw then there is a short in the armature winding.

Testing disassembled wiper motor

Testing armature:

- 1 - If the commutator is oily or dirty, it can be cleaned with a clean cloth moistened with cleaning solvent. If the commutator shows signs of wear or burning, it must be repaired. The commutator may be turned down to a minimum diameter of .846 in. (21.5 mm). The insulation between the segments must afterwards be reworked with a commutator saw. When doing this, ensure that no metal chips remain between the segments and so cause a short circuit between the armature windings. The permissible runout of the armature is .001 in. (0.03 mm).
- 2 - Often, armature damage cannot be seen. The armature, commutator and field windings are tested in the same way as a D. C. generator.

Wiper blades**Care**

For good visibility and safety, the windshield wipers should always be in good operating condition.

During long, dry period the wiper blades become clogged with road tar, oil droplets and dead insects. In this condition the wiper blades cannot completely remove the water film from the windshield.

To clean the blades thoroughly it is necessary to take them off and scrub them with a hard nylon brush and alcohol or a strong detergent solution. If the blades show cracks or signs of deterioration and the edges are no longer sharp, they should be renewed.

Notes:

Often the quality of the wiped area cannot be improved simply by replacing the wiper blades (see chart "Wiper Blade Troubles — Causes and Remedies"). In such cases the windshield must be treated with silicone remover. The following solvents can be used for cleaning the windshield:

- 1 - Windshield cleaner (VW part no. 000 096 105).
- 2 - Clean windshield with benzene and then treat it with an acid solution consisting of 1 part hydrochloric acid and 9 parts water. Afterward, rinse thoroughly with clean water.

Note:

- 1 - When cleaners containing silicones are used, the brushes, sponges, leathers and rags used to clean the paintwork should not be used for the windshield.
- 2 - The wiper blades are subject to a certain amount of natural wear even if given the best of care. It is advisable, in the interest of road safety, to fit new blades about every 12 months or earlier if necessary.

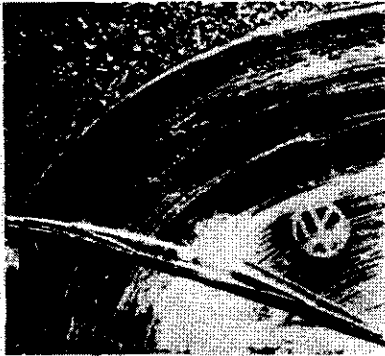
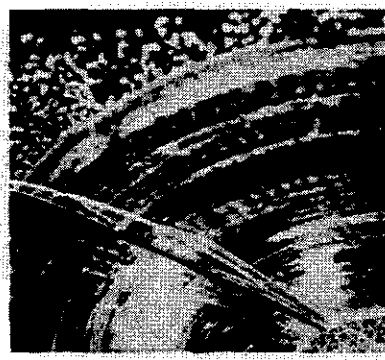
Park position

To ensure that the wiper motor always moves to its park position, note the following:

- 1 - Blades which have frozen to the windshield should be freed before operating the wiper switch. If this is not done, the blades may move slightly when turned on and then stop again. Should this occur at the turned on position, the current supply to the motor will continue as long as ignition is on, despite the fact that the switch has been turned off. This will cause the armature winding to burn out and make the motor unserviceable.
- 2 - When snow is falling, ensure that it does not build up on the windshield and prevent the blades from reaching the park position.

Symptoms	Cause	Remedy
Motor runs too slowly, cuts out or stops completely	- a - Ground connection or feed cable making poor contact - b - Brushes worn or sticking - c - Brush springs weak - d - Commutator dirty - e - Wiper bearings and linkage joints dry or jamming - f - Battery voltage too low	- a - Provide good contact to ground or for feed cable - b - Install new or free off brushes - c - Install new brush springs - d - Clean commutator - e - Lubricate bearings and linkage joints with universal grease - f - Charge battery; check cables and connections
Motor does not stop exactly in end position when switched off	- a - Contacts in wiper gear cover dirty, bent or broken - b - Open circuit in cable to terminal 53a of motor - c - Crank moved on spindle - d - No circuit between switch terminal 31—31 b - e - Contact 31 b broken or bent	- a - Clean contacts or replace gear cover - b - Check cable connections for contact - c - Let motor run to end position, loosen crank, move to correct position and re-tighten - d - Install new switch - e - Straighten contacts or replace cover and contacts
Motor continues to run when switched off	- a - Contacts in wiper gear cover bent - b - Contacts in switch burnt	- a - Check contacts, if necessary replace cover and contacts - b - Install new switch
Motor will not run or stops	- a - Armature burnt by winding or ground short circuit - b - Switch contacts burnt - c - As for "Motor runs too slowly, cuts out or stops completely"	- a - Install new motor or armature - b - Install new switch
Squeaking noise when motor operates and in some cases motor runs slowly	- a - Wiper shafts or drive bearing without grease - b - Gear housing not correctly located on body - c - Armature or worn gear bearing stiff	- a - Lubricate with universal grease - b - Correct location of gear housing - c - Set axial play, if necessary lubricate with molybdenum disulfide grease

The following table contains various wiper blade troubles with probable causes and remedies.

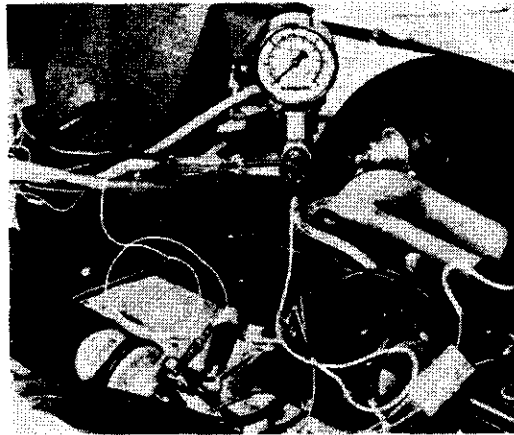
Symptom	Cause	Remedy
1 - Smearing 	a - Blade dirty b - Frayed blades lips, rubber damaged or worn out c - Old blades, edges cracked	a - Clean rubber with hard nylon brush and soap solution or methylated spirits b - Install new blades c - Install new blades
2 - Traces of water left in blade range form beads 	a - Glass soiled by polish, oil or diesel exhaust deposits	a - Clean windshield with clean cloth and grease-oil-silicone remover (E 5.3/1-2)
3 - Blade wipes well on one side and badly on other, judders 	a - Blade distorted to one side, no longer "flips" b - Wiper arm distorted, blade not vertical on windshield c - Glass dirty, thin film of water on it	a - Clean blade with hard nylon brush and soap solution or methylated spirits or fit new rubber b - Twist arm carefully until it is vertical c - Add glass cleaner to washer fluid
4 - Blade misses parts of windshield	a - Blade torn out of retainer b - Blade not contacting glass uniformly due to distorted spring or retainer c - Pressure exerted by wiper insufficient	a - Push blade back into retainer b - Install new blade. This defect is often caused by careless fitting of blades c - Oil arm linkage and spring sparingly or install new arm

Testing oil pressure switch

The oil pressure switch can be tested on the engine, using a simple testing device with a gauge (local manufacture drawing VW 622/2) and a test light, after the engine has reached operating temperature (about 70° C / 180° F) oil temperature).

- 1 - Remove oil pressure switch and install into testing device.
- 2 - Screw testing device into seat for oil pressure switch on crankcase and connect test light to oil pressure switch and to terminal 15 of ignition coil. When the ignition is switched on, the test lamp should light up. If the light does not light up, the switch is defective and must be replaced.
- 3 - Start engine. The light must go out when the gauge indicates a pressure above 2—6.5 psi. At a lower pressure the contact should remain closed and the light comes on. When the engine is cold, the lamp should go out at normal idling speed and when the engine is warm, the lamp should go out as the engine speed increases.
- 4 - Increase engine speed. At 2500 rpm the oil pressure should be 28 psi.
- 5 - Stop engine. A slight delay may occur before the light comes on. This is because the oil pressure drops slowly.

The oil pressure switch cannot be repaired.



Horn

An electromagnet in the horn produces pulsations in connection with a set of contact points. These pulsations are transmitted to a diaphragm which produces the sound. A condenser between the contact points reduces arcing and burning. Operation of the horn is by a button on the steering wheel hub, which closes the circuit with ground (negative terminal of battery).

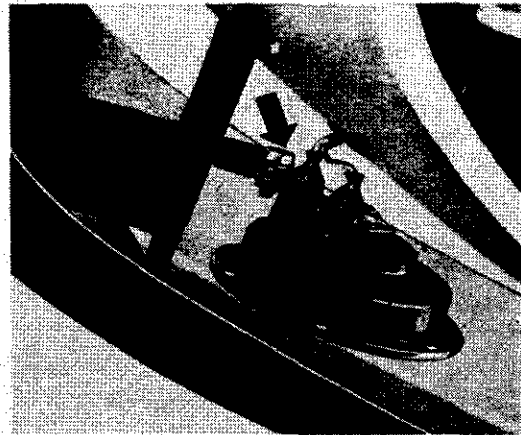
Removing horn

- 1 - Disconnect wires at horn and remove hexagon head bolt and nut from bracket on bumper bracket (arrow).

Installing

When installing, care should be taken that the horn bracket is not damaged and the horn does not touch the vehicle body, as the vibration of the diaphragm will otherwise be affected. Damage may result from worn or dirty breaker points, ingress of water and a faulty condenser.

If trouble is experienced with the horn, always check for faults in the wire from fuse box to horn or from the horn via the horn lever to ground. Corroded or loose connections often affect the operation of the horn.



Description

The lead-acid battery stores the electrical energy produced by the alternator. When starting the engine, the starter and ignition systems are supplied with the necessary current by the battery. Each of the battery cells has a set of positive lead oxide plates and a set of negative lead plates. The cells are in an acid proof container and are connected in series. The electrolyte has a specific gravity of 1.285. The positive terminal has a larger diameter than the negative terminal. In addition, the terminals are marked + and —.

Cell voltage

The nominal voltage of a cell is 2 volts. When the battery is being charged the available cell voltage increases to about 2.5—2.7 volts, but once the charging current is turned off, this drops to 2—2.1 volts (12—12.6 volts for the complete battery) in a very short time. When the available battery voltage has dropped to 10.5 volts in an unloaded condition, the battery is fully discharged.

Capacity

The capacity of a battery is the amount of current it can deliver for 20 hours at an electrolyte temperature of 81° F (27° C). This is given in Ah (ampere hours). A 54 Ah battery can deliver a current of 2.25 amps. for 20 hours at a temperature of 81° F (27° C).

Discharging process

As the battery discharges, the plates absorb more and more chemical parts of the sulphuric acid and turn into lead sulphate. This reduces the specific gravity of the acid (1.12 at 68° F/20° C in the discharged state).

Charging process

Lead-acid batteries can only be charged with direct current.

On the vehicle this current is supplied by an alternator. It is essential that the positive and negative poles of the direct current source be connected to the correct poles on the battery. Under the influence of the direct current, which should have a voltage of 2.7 volts for each cell, the positive plates turn back to brown lead oxide and the negative plates to spongy lead. The sulphuric acid which was absorbed into the plates during the discharging process is released again and this increases the specific gravity of the diluted acid to 1.285 (in fully charged state at 68° F/20° C). If the charging process is continued, the water in the battery acid electrolyses into hydrogen and the battery starts to "gas".

Specific gravity of electrolyte

The specific gravity of the battery electrolyte and a voltage measurement indicate accurately the state of charge of a battery. The specific gravity is checked with a hydrometer which consists of a glass cylinder housing with a rubber ball and a freely moving float with a calibrated scale. The higher the specific gravity of the electrolyte, the higher the float will rise in the liquid. The density of the acid can then be read off the scale as specific gravity. The following values should be attained:

State of charge	Specific gravity	Specific gravity in tropics
Fully discharged	1.12	1.08
Half discharged	1.20	1.14
Fully charged	1.285	1.23

Cold weather operation

The conductivity and degree of viscosity of the electrolyte largely depend on temperature. Extreme cold reduces the battery capacity considerably. At an electrolyte temperature of -13°F (-25°F) the capacity is only 50% of that at a temperature of $+68^{\circ}\text{F}$ ($+20^{\circ}\text{C}$).

The higher the specific gravity of the electrolyte, the lower its temperature must be before it freezes. The battery must, therefore, be kept in a sufficiently charged condition to prevent it from freezing. A frozen battery gives no current but can usually be restored by thawing out and recharging.

Specific gravity	Freezing temperature	
1.285	(-85°F)	-65°C
1.18	(-9°F)	-22.5°C
1.14	($+9^{\circ}\text{F}$)	-13°C

The increased stress imposed on the battery at low temperatures by the starter necessitates a more frequent inspection. In the cold season, it is recommended that the battery be removed at 4 week intervals for recharging and checking specific gravity and electrolyte level.

Taking batteries out of service

Batteries which are not used for prolonged periods gradually discharge. At normal room temperature the discharge rate is about 1% of the battery capacity per day. When a discharged battery is stored in a warm room, the plates also tend to "sulphate". This is the formation of a layer of lead sulphate on the plates. Sulphated batteries cannot supply the heavy current required to start the engine and are therefore unserviceable.

When a battery is to be taken out of service for a long time, the following points should be noted in order to prevent self-discharging and sulphating.

- 1 - Charge battery, check acid level and specific gravity and rectify as necessary.
- 2 - Store the battery in a cool dry place, discharge it every 6—8 weeks and then re-charge.
- 3 - Before a battery is put back into regular use, it should be charged at a very low rate (maximum 3 amp.).

Sulphated batteries must be "boosted" at a high charging rate under any circumstances as this can damage them seriously.

Using pre-charged batteries

When putting pre-charged (dry-charged) batteries into use, follow the battery manufacturer's instructions.

The procedure is usually as follows:

- 1 - Store batteries in a cool, dry place.
- 2 - Remove cell plugs and fill cells with electrolyte with a specific gravity of 1.285 at $+68^{\circ}\text{F}$ ($+20^{\circ}\text{C}$).
- 3 - After about 15 minutes, shake battery slightly and add battery electrolyte to bring level up to mark.
- 4 - The battery can now be connected and treated in the same way as any other battery.

Battery care

The average service life of a battery is two to three years. This is due to such conditions as prolonged attempts to start engine (as much as 300 amp. current draw) and vibration while the vehicle is operated.

The battery must be fixed securely in the vehicle and the terminal pillars and terminals must be kept clean to avoid high contact resistances. The connections should be wiped with a clean rag or, when very dirty, with a special pole cleaner. Afterward, they should be coated sparingly with an acid resistant grease or petroleum jelly.

Battery connections that are hard to remove because of oxidation can be pulled off with a special tool.

Important

The plastic casing of the battery must not come into contact with grease, oil or gasoline, otherwise discoloration cannot be avoided.

